Organic Research at the USDA, Agricultural Research Service Is Taking Root

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ABSTRACT. The U.S. Department of Agriculture/Agricultural Research Service (USDA/ARS) began to coordinate its effort in organic agricultural research in 2000 by initiating a survey to determine the

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nature and extent of organic research being conducted by agency scientists. The survey revealed that approximately 9% of scientists within the agency were interested in organic agriculture but that less than 4% had actually participated in research in certified or certifiable organic production systems. With few exceptions, scientists conducted research on working or transitioning organic farms. Regardless of whether the research was conducted on farm or on research-station-managed land, farmer participation varied greatly. The USDA/ARS is in the process of coordinating the national organic research effort and has invited organic growers and other professionals to participate in the planning process in order to ensure that organic research at the agency continues to be rooted in its interactions with organic stakeholders. doi:10.1300/J484v12n04_02

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INTRODUCTION

Over the past 10 years or more, there has been an increased demand for organic products by consumers that has, in turn, increased organic production and processing pressures. Organic agriculture remains the fastest growing sector of the agricultural economy in the United States and worldwide (Dimitri and Green, 2002; OECD, 2002). This sector is estimated to be worth approximately U.S. $26 billion (OECD, 2002). Although it accounts for between 2 and 10% of agricultural production in developed countries, the growth of this sector has ranged from 15 to 30% annually for the last 10 years. In the United States, growth has paralleled that of other developed nations with the annual growth in retail sales topping 20% or more (Dimitri and Green, 2002). Before the 1990s, almost all organic products were sold at specialty food stores, but now approximately 44% of organic sales are made in conventional food markets (Dimitri and Oberholtzer, 2006). In step with retail sales, organic crop and pasture acreage increased 1.7- and 1.5-fold to 1.45 million acres (587,250 ha) and 745,000 acres (301,725 ha), respectively between 1997 and 2003. This rapid growth in demand has produced tensions in organic production as well as in markets.

The growth in organic production has necessitated an equivalent growth in organic agricultural research, and research institutions have begun to

respond. A rise in scholarly publications presenting research in organic agriculture is one piece of evidence that organic agriculture has become a fruitful area of research for scientists (Bull, 2006). New and increased funding as well as strong administrative support in research institutions has spurred this growth. Over the past 10 years Federal and State research institutions have joined the non-governmental organizations and organic producers (the primary innovators in organic agriculture and driving force in organic agricultural research) in a commitment to investigate research problems of importance to this sector of the agricultural economy (Sooby, 2001, 2003).

THE ARS ORGANIC RESEARCH PORTFOLIO

Research and dissemination of information in organic agriculture at the federal level falls within the mission of several agencies within the USDA. Many programs and agencies have had significant impacts on organic agricultural research and education and have played vital roles in elevating the needs of organic stakeholders to a higher priority within the USDA. A review of the activities on organic agriculture within various programs in the USDA was previously published by Dimitri and Greene (2002). Current ambitious work by these agencies should have a significant impact on our understanding of the U.S. organic industry at all levels.

In this article the focus is on the Agricultural Research Service (ARS), "the U.S. Department of Agriculture's chief scientific research agency" (Anonymous, 2006). The vision of this agency is "to lead America towards a better future through agricultural research and information." The ARS has 2,100 scientists working on approximately 1,200 research projects. The research projects are coordinated through 22 National Programs and these are currently organized in four themes: (1) Nutrition, Food Safety/Quality; (2) Animal Production and Protection; (3) Natural Resources and Sustainable Agricultural Systems; and (4) Crop Production and Protection. The areas of expertise needed for organic research fall into each of the four national program areas and one or more organic research projects are administratively aligned to most of the national programs. For example, as part of National Program-308 several scientists are working to improve organic systems as potential alternatives to methyl bromide, a soil fumigant whose complete ban is imminent. National Program-207 (Integrated Agricultural Systems) has provided central coordination for organic research in all ARS

national programs over the past eight years, although NP207 is not strictly limited to organic research.

The history of the bumpy relationship between the USDA and the organic industry are presented elsewhere (Bull, 2006; Jawson and Bull, 2002; Duram and Larson, 2001; Lipson, 1997; Paar, 2003; USDA, 1980). Official interest by the USDA in organic agriculture was significant in the late 1970s. A collaboration among employees of several federal and state agencies resulted in the "Report and Recommendations on Organic Farming" by the USDA Study Team on Organic Farming (USDA, 1980). The report indicated that at the time of the study only 1% of the ARS budget represented research in sustainable agriculture. Although this report was widely acclaimed as an authoritative treatise on organic agriculture, soon after its publication, organic agriculture was removed from the official USDA program.

After organic research was dropped from the official USDA/ARS agenda, organic research became difficult to find or conduct, although some ARS researchers continued to work quietly in this area. Again in the late 1990s, pressure was placed on the ARS as well as other agencies in the USDA to increase their service to organic stakeholders. Since Lipson's (1997) watershed publication, "Searching for the O-Word," showed that less than one-tenth of one percent of the USDA's research portfolio consisted of "strong organic projects," ARS has added a number of organic research projects. However, no documentation system was put in place to track the explicit organic nature of ARS research programs, and by 2000 there was again no clear understanding of the USDA/ARS organic research portfolio. As a result, a new analysis was initiated, surveying the level of interest and participation in organic agricultural research by USDA/ARS scientists. Some details of the survey methods have been reported previously (Bull, 2006).

Approximately 9% of USDA/ARS scientists responded to the survey and indicated that they were interested in organic agriculture research, although many had not yet worked in organic systems. Of the 192 respondents, 88 respondents (4% of all USDA/ARS scientists) said that they were working in, or had worked in, organic systems that were certified or certifiable. Only 4 of the 88 scientists stated that 100% of their research was directly applicable to organic agriculture.

Since 2002, the number and size of organic research projects and the ranks of associated ARS scientists have grown. Some program has developed as the result of acquiring competitive funding and in other cases new programs have been added to specifically address organic agricultural needs. For example, ARS scientist Dr. Mark Mazzola, of

the Tree Fruit Research Center in Wenatchee, Washington, as part of a competitive proposal process, received USDA/CSREES (Cooperative State Research and Education and Extension Service) funding in 2004 in support of his project: Use of Resident Biological Resources for the Management of Replant Disease in Organic Tree Fruit Production Systems. Initial work on this project was funded by ARS, but USDA/CSREES provided funds to significantly expand the work. Additionally, the project "Grain Production and Use on Organic Dairy Farms in Maine and Vermont" at the Orono, Maine station was initiated in 2006. This particular project is significant since at the time of the survey, less than 2% of the scientists interested in organic agriculture worked in animal systems. The overall increase in interest by ARS scientists is promising considering the significant obstacles described by the researchers in the survey (Bull, 2006). Presented here are findings related to the obstacles and benefits of different strategies researchers used for conducting organic research.

ORGANIC AGRICULTURAL RESEARCH IS ROOTED IN GROWER EXPERIENCES

Organic agriculture research strives to provide information of direct value to growers or other stakeholders to provide organic products of high value to consumers. Although it wasn't always clear, most researchers now understand the need for organic agriculture research to be conducted in an explicitly organic setting (Lipson, 1997; Sooby, 2001, 2003; Yandoc et al., 2004). Additionally, it is clear to most researchers and stakeholders that strong grower participation in projects is a keystone to relevant organic research because organic growers are the primary innovators of organic agriculture (Lipson, 1997; Sooby, 2001, 2003; Yandoc et al., 2004). Although many other factors must be considered for designing effective organic agricultural research programs, grower participation, and availability of organic land for research are two of the first considerations researchers face in designing their programs. Therefore, these factors are of direct consequence to the expansion of USDA/ARS organic research projects.

Of the 88 ARS scientists who have conducted organic research in explicitly organic settings, all reported that they have worked directly with organic growers. ARS scientists conducted their projects on research stations or on grower land. However, the location of the research project did not appear to influence the extent of grower involvement. Different

projects required different levels of grower involvement. Many combinations of research strategies are needed for successful organic research (Lockeretz, 2002), and individual researchers from the USDA/ARS have chosen those strategies that made the most sense for their projects.

ORGANIC RESEARCH AT GOVERNMENT-MANAGED FACILITIES

For experiments that require specific and time-consuming comparisons and treatments that need to be meticulously applied, researchers may choose to conduct research on land managed by research professionals rather than on growers' fields due to the high cost of managing small plots (Karlen et al., personal communication, 2006; Rzewnicki et al., 1988) and sometimes conflicting priorities of research and commercial production. However, at the time of the survey, only one USDA/ARS research station had certified organic research land available. Dr. Eric Brennan actively manages approximately 22 acres of certified land for the research project: Cover Cropping Practices to Improve Weed and Fertility Management in Organic Production Systems, located in the Crop Improvement and Protection Research Unit at Salinas, CA. Other organic vegetable research programs have land that is certifiable, but lacks certification for administrative reasons. For example, the 11 acres of organically managed ground in the Long-Term Field Experiment to Evaluate Sustainability of Organic and Conventional Cropping Systems project in Beltsville, MD, is on certifiable, but not certified, land. Dr. Michel Cavigelli has 11 years of data from this project and since the 2002 survey, an additional 22 acres (8.9 ha) of ARS land was certified. Additional strategies include the development of long-term leases or collaborations (Drs. Dan Chellemi and Erin Rosskopf, Fort Pierce, FL), or work with non-governmental agencies, to provide long-term access to certified or certifiable land (the project in Morris, MN, for example). Other researchers used small plots on conventional land that were managed according to organic practices.

As part of the 2000 survey, scientists were asked to describe obstacles that significantly hinder research in organic agriculture. ARS scientists described several obstacles relating directly to projects on land managed by ARS. One obstacle was the increased cost of organic programs that needed to interface with conventional programs. Because conventional farming programs have long been established at these locations, organic research programs are expected to fit with existing

programs without changing the functionality or costs of the latter. One obstacle mentioned repeatedly is that land available for certification was not always the prime quality land on the research farm and was in some cases the land that other projects did not want to use. Although this increases the difficulties the researcher faces when transitioning the land to organic use, this may be representative of some growers' strategies for transition. During a survey of strawberry growers for the Biological Agricultural Systems in Strawberry and Organic Agriculture Systems in Strawberry project (funded by UC-SAREP), several growers said they transitioned their worst land to organic because they did not want to risk returns from their best-quality land (Bull et al., unpublished data).

In addition to land availability, farm equipment use is generally an issue for researchers initiating organic research on ARS-owned or controlled land. Available equipment is regularly used by the pre-existing conventional agricultural programs. Organic researchers' programs usually bear the cost of cleaning this equipment to remove pesticides and other substances that are not permitted in organic production. An additional problem mentioned by organic researchers is potential chemical contamination due to shared irrigation or run-off from adjacent conventional agricultural research fields. In more than one case, this also has resulted in an increased economic burden solely on the organic research programs. The result is that independent infrastructure is often developed for the organic programs to ensure the integrity of the organic system (Watson and Atkinson, 2002).

When research is conducted on ARS land managed by ARS personnel, a significant challenge is to ensure that research remains relevant. Stakeholder involvement in research is one way to accomplish this. In general, the scientists in the individual ARS programs have worked hard to develop relationships with organic growers who provide direct input for experiments conducted at the research stations. However, according to the survey, stakeholder involvement in research conducted on ARS land varied from little involvement to elaborate agreements in which the grower manages the organic land and works as a partner with the researchers to conduct the experiments.

In addition to the issue of relevance to local stakeholders, scientists discussed concerns about transferability of organic practices and knowledge from one environment and system to another across the country, or even from the research farm to commercial farms. They are concerned that their research will not be broadly applicable if conducted in a regional organic farming system. This is a valid concern, as many

of the practices involved in successful organic farming are specific to geography, climate, resident pests, market, etc. Scientists must be informed about the unique mixes of crops and approaches that growers use on individual farms, while at the same time conducting research that meets rigorous scientific criteria and is broadly relevant. The scientists may find that they have to run an organic farming operation in addition to their research program.

ORGANIC RESEARCH ON GROWER-MANAGED LAND

Most ARS scientists reported that they exclusively were using the second major strategy, conducting research on commercial organic farms, in part because ARS has so little organically managed and certified land. Even those scientists who have access to ARS-managed organic land frequently work on farm for the benefits that this approach offers. There are several obvious benefits to conducting research on farm, many of which have been described previously (Lockeretz, 1987; Rzewnicki et al., 1988; Vogl et al., 2004; Yandoc et al., 2004). Some benefits include: Elimination of costs to the researchers of development of certified land, greater potential for organic relevance, and a direct opportunity for technology transfer.

The overwhelming benefit of on-farm research on established organic farms is that neither the land, nor the grower, will go through a transition process while the research is being conducted. Transition is often experienced when new organic programs are developed on ARS lands. Transitions in grower knowledge and the ecological status of the land have been implicated in what is known as the "transition effect" (Drinkwater et al., 1995; Martini et al., 2004; Scow et al., 1994). This is a production period in which organic farms measurably do not function at the optimal levels reached by "mature" organic systems (Liebhardt et al., 1989; Lockeretz et al., 1981; MacRae et al., 1990; Temple et al., 1994; USDA, 1980). By working with established organic growers on certified organic farms, researchers can avoid this transition period and the possibility of associated spurious experimental results.

Experiential science indicates that the researcher is also an actor in the system that they study (Alrøe and Kristensen, 2002; Baars and Wagnaar, 2002). In the case of would be organic researchers or research administrators with conventional training, they may also go through a transition period. This transition may not only involve the learning of organic production methods, but may also involve developing an understanding

of the social and economic context for organic research (Alrøe and Kristensen, 2002; Dabbert, 2006; DuPuis, 2006; Holling, 1997; Niggli, 2002) and alternative experimental models that include analysis of complex on-farm systems rather than just factorial designs in small plots (Drinkwater, 2002; Rzewnicki et al., 1988; Lockeretz, 2002; Niggli, 2002; Riley and Alexander, 1997). By understanding the nature of the transition period for researchers and/or administrators for work in organic systems, we may be able to increase the learning curve so that researchers are up to speed sooner and help universities to design courses to train these scientists.

Although it seems self-evident that research conducted on grower land would have strong grower involvement, in some cases growers donated certified land, but were not further involved in the research. Approximately 10% of the ARS scientists working in organic agricultural research were working on growers' land, but had little additional input from the growers. At the other extreme, projects were reported for which growers managed most production aspects with input by researchers, and in some cases took most of the economic risk and were intimately involved in the research plans. Participatory research has been emphasized by growers and stakeholders as a principle for ensuring relevancy and technical transfer of organic research (Duram and Larson, 2001; Gibbon, 2002; Niggli, 2002). Over a quarter of the ARS researchers working in organic systems reported that their research involved grower participatory models. The survey clearly indicated that regardless of whether the research was conducted on farm or on land managed by a research institution, grower involvement varied greatly.

Some research obstacles were common to research on ARS land and on-farm locations. For example, issues related to systems research approaches, administrative support, funding, and how to ensure relevancy to local, regional, and national organic stakeholders were reported to be problematic to research located on farm, or at research stations.

Grower cooperators are essential to ARS organic research. Unfortunately, 28% of the obstacles identified by ARS scientists involved issues with grower cooperators. These obstacles included the inability of some ARS scientists to find organic growers with whom to work. Mistrust of researchers, or the previous lack of interest by researchers from mainstream institutions, may play a role in the apparent lack of organic cooperators (Carnes and Karsten, 2003; Lipson, 1998; Sooby, 2001, 2003). Additionally, the cost of participating in research projects may be more expensive to organic growers. Additionally, if the research results in increases in pest pressures, there are no quick fixes to alleviate them.

Also, ARS scientists indicated that in some locations there just were no local organic growers. Although there may be a dearth of organic growers in some cropping systems and locations, many organic growers have indicated their willingness to cooperate in scientific research (Walz, 1999).

Another issue discussed was the consistency of growers' commitment to research projects. It was understandable to most researchers that changes in economic imperatives for some growers would result in changes in their commitment during the course of the research. More than one scientist experienced the loss of several years of research because a grower needed to quit experiments before they were completed. This frustrates scientists because they feel as though they have wasted the limited time and economic resources allocated to the project. This problem is not confined to organic producers, and has been experienced with cooperators who farm conventionally. However, this problem may be minimized by carefully selecting the appropriate research management model for each research project. Moreover, including growers from the beginning of the research planning process as equal partners may help to alleviate this problem.

ORGANIC RESEARCH AT THE USDA/ARS WILL LIKELY CONTINUE TO GROW

As part of the 2000 survey, ARS scientists indicated that there was a lack of support and approval for organic research by USDA/ARS administrators. That obstacle seems to be on its way to being alleviated. Since 2002, significant steps have been taken by the ARS administration to demonstrate support for this area of research. In January 2005, the first USDA/ARS Workshop on Organic Agriculture was held in Austin, TX and was attended by 63 scientists. Several significant results developed out of this meeting, including the drafting of an action plan that included reestablishing a position at the national level specifically to coordinate organic agriculture research in the USDA/ARS. It was thought that a specific position dedicated to management of the organic research programs crossing all national programs would demonstrate the intent of the agency to increase organic research and give an official level of legitimacy to research in this area. The development of regional organic research centers was another suggestion. Regional organic research stations could provide organic land and know how.

In October 2006, ARS scientists again met with organic stakeholders at the National Program-216 workshop. Further interactions between

researchers and industry are likely outcomes, since input from organic stakeholders is the main emphasis of this meeting. Organic stakeholder involvement continues to be essential to maintain the integrity of consumer's demand and to maintainproject relevance as organic agricultural research continues to expand in the ARS.

LITERATURE CITED

Alrøe, H. F. and E. S. Kristensen. 2002. Towards a systemic research methodology in agriculture: Rethinking the role of values in science. Agric. Human Values 19: 3-23.

Anonymous. 2006. About ARS. (Available online at: http://www.ars.usda.gov/AboutUsAboutUs.htm).

Baars, T. and J. P. Wagenaar. 2002. Experiential science as a novel scientific discipline, pp. 115-116. In: Powell et al. (eds.). UK Organic Research 2002: Proceedings of the COR Conference, Aberystwyth, 26-28, March 2002.

Bull, C. T. 2006. U.S. Federal organic research activity is expanding. Online. Crop Management doi:10.1094/CM-2006-0921-18-RV.

Carnes, L. M. and H. D. Karsten. 2003. Building diverse community networks for sustainable food systems: Guiding philosophies of the Pennsylvania Association for Sustainable Agriculture. Am. J. Alt. Agric. 18: 174-184.

Dabbert, S. 2006. Measuring and communicating the environmental benefits of organic food production. Online. Crop Management doi:10.1094/CM-2006-0921-13-RV.

Dimitri, C. and C. Greene. 2002. Recent growth patterns in the U.S. organic foods market. United States Department of Agriculture Economic Research Service, Agriculture Information Bulletin Number 777.

Dimitri, C. and L. Oberholtzer. 2006. A brief retrospective on the U.S. organic sector: 1997 and 2003. Online. Crop Management doi:10.1094/CM-2006-0921-07-PS.

Drinkwater, L. E. 2002. Cropping systems research: Reconsidering agricultural experimental approaches. HortTechnology 12: 355-360.

Drinkwater, L. E., D. K. Letourneau, and C. Shennan. 1995. Fundamental differences between conventional and organic tomato agroecosystems in California. Ecol. Appl. 5: 1098-1112.

DuPuis, E. M. 2006. Civic markets: Alternative value chain governance as civic engagement. Online. Crop Management doi:10.1094/CM-2006-0921-09-RV.

Duram, L. A. and K. L. Larson. 2001. Agricultural research and alternative farmers' information needs. Professional Geographer 53: 84-96.

Gibbon, D. 2002. Systems thinking, interdisciplinarity and farmer participation: Essential ingredients in working for more sustainable organic farming systems, pp. 105-108. In: Powell et al. (eds.). UK Organic Research 2002: Proceedings of the COR Conference, Aberystwyth, 26-28 March 2002.

Holling, C. S., F. Berkes, and C. Folke. 1997. Science, sustainability and resource management, pp. 342-362. In: F. Berkes and C. Folk (eds.). Linking social and ecological systems: Management practices and social mechanisms for building resilience. Cambridge University Press, New York.

Jawson, M. D. and C. T. Bull. 2002. USDA research into organic farming. Am. J. Alt. Agric. 17: 201-202.

Liebhardt, W. C., R. W. Andrews, M. N. Culik, R. R. Harwood, R. R. Janke, J. K. Radke, and S. L. Rieger-Schwartz. 1989. Crop production during conversion from conventional to low-input methods. Agron. J. 81: 150-159.

Lipson, M. 1997. Searching for the "O-Word." Organic Farming Research Foundation. Santa Cruz, CA.

Lockeretz, W. 1987. Establishing the proper role for on-farm research. Commentary. Am. J. Alter. Agric. 3: 132-136.

Lockeretz, W. 2002. Strategies for organic research, pp. 25-31. In: Powell et al. (eds.). UK Organic Research 2002: Proceedings of the COR Conference, Aberystwyth, 26-28 March 2002.

Lockeretz, W., G. Shearer, and D. Kohl. 1981. Organic farming in the Corn Belt. Science 211: 540-547.

MacRae, R. J., S. B. Hill, G. R. Mehuys, and J. Henning. 1990. Farm scale agronomic and economic conversion from conventional to sustainable agriculture. Adv. Agron. 43: 155-198.

Martini, E. A., J. S. Buyer, D. C. Bryant, T. K. Hartz, and R. F. Denison. 2004. Yield increases during the organic transition: Improving soil quality or increasing experience? Field Crops Rsch. 86: 225-266.

Niggli, U. 1999. Holistic approaches in organic farming research and development: A general overview, pp. 33-39. In: R. Zanoli and R. Krell (eds.). First SREN Workshop on Research Methodologies in organic Farming. REU Technical Series 58. FAO, Rome, Italy.

Organization for Economic Cooperative Development (OECD). 2003. Organic Agriculture: Sustainability, markets and policies. CABI, Wallingford, UK, 375 pages.

Paar, J. F. 2003. USDA research on organic farming: Better late than never. Am. J. Alter. Agric. 18: 171-172.

Riley, J. and C. J. Alexander. Statistical literature for participatory on-farm research. Expl. Agric. 33: 73-82.

Rzewnicki, P. E., R. Thompson, G. W. Lesoing, R. W. Elmore, C. A. Francis, A. M. Parkhurst, and R. S. Moomaw. 1988. On-Farm experiment designs and implications for locating research sites. Am. J. Alt. Agric. 3: 168-173.

Scow, K. M., O. Somasco, N. Gunapala, S. Lau, R. Venette, H. Ferris, R. Miller, and C. Shennan. 1994. Transition from conventional to low-input agriculture changes soil fertility and biology. Calif. Agric. 48, 20-26.

Sooby, J. 2001. State of the States: Organic farming systems research at land grant institutions 2000-2001. Organic Farming Research Foundation, Santa Cruz, CA.

Sooby, J. 2003. State of the States, Second Edition: Organic Farming Systems Research at Land Grant Institutions 2001-2003. Organic Farming Research Foundation, Santa Cruz, CA.

Temple, S., D. B. Friedman, O. Somasco, H. Ferris, K. Scow, and K. Klonsky. 1994. An interdisciplinary, experiment station-based participatory comparison of alternative crop management systems for California's Sacramento valley. Am. J. Alt. Agric. 9: 64-71.

USDA Study Team on Organic Farming 1980. Report and recommendations on organic farming. Washington, DC: United States Department of Agriculture.

Vogl, C. R., G. Lissek-Wolf, and A. Surböck. 2004. Comparing hemp seed yields (*Cannabis sativa* L.) of an on-farm scientific field experiment to an on-farm agronomic evaluation under organic growing conditions in lower Austria. J. Indust. Hemp 9: 37-49.

Walz, E. 2004. Final results of the Fourth National Organic Farmers' Survey: Sustaining organic farms in a changing organic marketplace. Organic Farming Research Foundation, Santa Cruz, CA. 106 pp.

Watson, C. A. and D. Atkinson. 2002. Organic farming: The appliance of science. pp. 13-17. UK Organic Research 2002: Proceedings of the COR Conference, Aberystwyth. 26-28 March 2002.

Yandoc, C. B., E. N. Rosskopf, and C. T. Bull. 2004. Weed management in organic production systems, pp. 213-254. In: R. Lartey and A. Caesar (eds.). Emerging concepts in plant health. Research Signpost, Kerala, India.

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